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Spraying Materials and the Control of Apple Scab

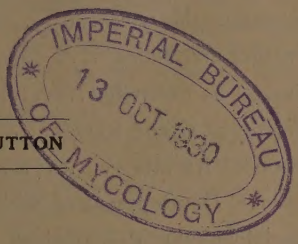

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TABLE OF CONTENTS

	Page
Introduction	3
Definition of Terms	3
Purpose of Experiments	5
Presentation of Data	5
Methods of Grading of Fruit	5
Experiments at Morrice	5
Experiments at Belding	7
Experiments at Fennville	8
Experiments at Grand Rapids	9
Discussion of Results	9
Seasonal Development of Scab	9
Special Sulphur Preparations	10
Dry-Mix Sulphur-Lime and Wettable Sulphur	11
Dry Lime-sulphur	12
Lime and Other Materials in Combination with Lime-sulphur and Dry Lime-sulphur	15
Iron Sulphate with Lime-sulphur and Dry Lime-sulphur	17
Aluminum Sulphate with Lime-sulphur	18
Bordeaux	18
Lead Arsenate and Scab Development	19
Calcium Arsenate and Scab Development	20
Seasonal Use of Fungicides	20
What Concentration of Lime-sulphur is Best?	21
Summary	22
Acknowledgments	23
Appendix	24

Spraying Materials and the Control of Apple Scab

W. C. DUTTON

The control of scab has been and will continue to be one of the important problems of the Michigan apple grower. It always presents two major questions, which are the choice of the material or materials to use and the course of procedure to follow in their application. The procedure, or, as commonly called, the schedule of applications, has changed considerably during recent years as the result of more complete knowledge of the life history and behavior of the fungus (*Venturia inaequalis*) which causes apple scab. This procedure may vary somewhat from season to season, but in general it may be said that the grower must adhere fairly closely to a more or less standard procedure. This is still more desirable when the insects which also have to be controlled are taken into consideration.

The other phase of the problem, the choice of materials, is very complicated at present. Two materials, lime-sulphur and bordeaux, may be depended on to give satisfactory control of scab if properly used. Unfortunately, however, both have some undesirable qualities. Foliage injury, with its train of ill effects, and some russeting of the fruit may follow the use of lime-sulphur alone or with lead arsenate. Bordeaux usually causes rather serious russeting of the fruit.

Many new materials and modifications of the old ones have been offered for use on apples with the idea that these materials have properties which make them more desirable. The testing of these new materials is an important part of any comprehensive program of spraying investigations. Extensive tests of this sort have been made during recent years and the results of some of this work are presented in this publication.

DEFINITIONS OF TERMS AND MATERIALS

That there may be a clear understanding of the terms used in this report, definitions of some of the materials used are given here.

Lime-Sulphur—The standard, commercial liquid concentrate testing 32 to 33 degrees Baume.

Dry Lime-Sulphur—The powdered or dry form of lime-sulphur which is made by dehydrating or drying the liquid concentrate and which contains compounds of sulphur similar to those found in liquid lime-sulphur. For use as a spray, it is dissolved in water. Dry lime-sulphur is distinct from dry-mix sulphur-lime. Two brands of dry lime-sulphur were used in these experiments. The one designated as

"dry lime-sulphur A" is the product of the Sherwin-Williams Company, and "dry lime-sulphur B" is from the Dow Chemical Company.

Dry-mix Sulphur-Lime—A mechanical mixture of sulphur, hydrated lime, and some wetting agent such as casein spreader. This preparation is frequently called simply "dry-mix." It is mixed with water and applied as a spray. Many manufacturers of spraying materials offer, under trade names, preparations that are essentially the same as "dry-mix."

Wettable Sulphur—Sulphur to which has been added some material to make it wettable, that is, to permit its being mixed with water. Ordinary sulphur does not mix easily with water. Wettable sulphur differs essentially from "dry-mix" in that it contains little or no hydrated lime.

Activated Sulphur—A specially prepared sulphur which has been treated in such a way that the effectiveness of the sulphur is supposed to have been increased.

Colloidal Sulphur—A very finely divided sulphur which is supposed to have special merit because of the extreme fineness of the particles.

Lime—Two kinds of lime have been used in this work, quick lime and hydrated lime. The kind used is indicated in each instance. The quick lime was high calcium lime. Some of the hydrated lime has been of the fine, finish lime but in 1928 and 1929 a high calcium lime specially prepared for spraying purposes was used.

Iron Sulphate—The iron-sulphate used was the ferrous sulphate. The crystalline form was used until 1929 when, for part of the work, the "sugar" or granulated form was used. The crystals were always dissolved into a stock solution before use. The "sugar" grade was dissolved by adding to water in the sprayer tank with agitation. The usual procedure was to add the ferrous sulphate, lead arsenate, and lime-sulphur in the order named.

Aluminum Sulphate—The aluminum sulphate, the commercial grade obtained in the form of a rather fine powder, was washed into the tank through the screen, as it is not easily made into a stock solution.

Calcium Sulphate—Gypsum, or calcium sulphate, was used in one instance. This was finely ground and only that which would pass through a 200 mesh screen was used. Some of the material was finer than 300 mesh.

Tobacco Dust—The tobacco used in this series of experiments contained, according to the producer's statement of analysis, one-half per cent actual nicotine and was of 100 mesh grade.

Lead Arsenate—The dry or powder form of the ordinary or acid lead arsenate was used in all experiments.

PURPOSE OF EXPERIMENTS

The primary object of these investigations has been to determine the fungicidal value of materials commonly offered for sale, or, in some cases, obtained from manufacturers or investigators for trial before being offered for sale.

Other objectives have been to determine the injurious effects, if any, the materials may have and the effect of these injuries on the performance of the tree. This report, however, deals primarily with the value of the materials in the control of apple scab.

PRESENTATION OF DATA

These investigations have been carried on in several orchards in central and western Michigan over a period of six years. A description of the orchards, a statement of the schedules and methods of spraying, equipment and pressures used, and other facts are given for each orchard. A tabular statement of materials, concentrations, and the degree of scab development is presented for each orchard in the appendix. A discussion of results and a summary is given for the work as a whole.

METHODS OF GRADING FRUIT

In some of this work, the fruit was classified simply as "scabby" or "scab free" and an apple that had any scab on it was classified as scabby. Later, however, the scabby fruit was divided into two grades. Fruit that was only slightly scabby and had a total area of scab not greater than an area one-half inch in diameter was called "B" grade. Fruit with scab more serious than that was classified as "C" grade or badly scabbed. This classification is in practical accordance with the Michigan apple grading law.

EXPERIMENTS AT MORRICE

The Orchard—The orchard at Morrice, Shiawassee county, is on the farm of Geo. F. Winegar. The trees were planted in 1912 and are in good state of vigor. The orchard which covers about 10 acres, is composed of blocks of Jonathan, Hubbardston, McIntosh, Baldwin, Wealthy, and Northern Spy as permanent trees, with Wagener fillers throughout. The blocks are so arranged that the experimental plots could be run across them and include as many of the varieties as desired. During the period of the experiments, a sod of alfalfa and various grasses has been maintained. The growth has been cut once or twice a year and

then raked up under the trees, or, in some instances, has been left where cut. A liberal mulch of straw has been applied under the trees. Moderate amounts of nitrogen-bearing fertilizer around the trees, and barnyard manure in an all-over application between the rows of trees have been applied regularly on most of the orchard.

Spraying Equipment and Methods—A spraying outfit with a rated capacity of 10 gallons per minute and operated with a four H. P. engine was used for all the spraying. A single nozzle spray gun of the short type, and disc with an aperture of 9/64 inch have been used at all times. The pressure maintained at the pump for each season was as follows: 1924, 300 lbs.; 1925, 1926, and 1927, 325 lbs.; and 1928 and 1929, 350 lbs. The pressure varied from these figures very little and for short periods only. In 1924, the spraying was done from the ground but since that time has been done from an extension platform at the rear of the sprayer, about 15 inches from the ground. When spraying from the ground, each tree was completed as a unit; when spraying from the platform each row was completed as a unit.

Schedule and Dates of Applications—This orchard has usually received five applications each year for scab control, the prepink, pink, petal-fall, two-weeks, and second brood sprays. No dormant spraying has been done. The dates of the several applications for each year are shown in Table I.

Table 1.—Dates of applications at Morrice.

Application	1924	1925	1926	1927	1928	1929
Prepink	May 2, 3	.....	.....	April 22*	May 2, 3	April 10, 11, 12
Pink	May 15, 16	May 4, 5	May 18, 19	May 4, 5	May 9	April 30, May 1, 2 †
Petal-fall	June 6, 7	May 21	June 1, 2	May 25, 26	May 25, 26	May 27, 28
Two weeks	June 19, 20	June 3	June 15, 16	June 8, 9	June 7, 8	June 7, 8, 10
Second brood	Aug. 12, 13	July 20, 21	Aug. 5, 6	Aug. 4, 5	Aug. 8, 9	Aug. 5, 6, 7

*The prepink application was made on McIntosh only and all the trees of that variety were sprayed with lime-sulphur, 2½ gallons, and water to make 100 gallons.

†Trees of Northern Spy were in a very early "green-tip" stage at the time the prepink was applied to the other varieties and in the prepink condition when the others were in full pink. The spy trees were sprayed again on May 13, when the blossom clusters were fully separated.

Supplementary Materials—Nicotine sulphate (40 per cent) has generally been used in the prepink or pink application. In 1927, it was not used until the second brood spray when it was applied to reduce a heavy summer infestation of the green apple aphid. Lead arsenate has been used regularly in all applications, except the pre-pink, unless otherwise indicated in the outline for each year. The amount used was two pounds in each 100 gallons of spray in 1924 to 1927 inclusive. In 1928 and 1929, three pounds were used in the pink, petal-fall, and two-weeks sprays and two pounds in the second-brood application. Any exceptions to these amounts are indicated with each outline.

Scab Development—There has been much seasonal variation in scab development. In 1924, scab developed freely during the early part of the summer and the results obtained that year are very significant. The late summer and early fall were very dry, however, and the spring of

1925 was also marked by light precipitation with the result that practically no scab developed during the season of 1925, even on unsprayed trees. The season of 1926 was also unfavorable to scab development in this orchard. The results obtained in 1925 and 1926 therefore cannot be considered as significant. In 1927, weather conditions were again favorable to the spread of scab and the period of heaviest development extended from the late blooming period into June, so that the petal-fall and two-weeks applications were the most critical for scab control. The fungus spread and developed very gradually during 1928, and scab could not be considered as epidemic. In 1929, there were frequent periods of rainfall which ordinarily would have been followed by heavy scab development, but this was not the case in this orchard, and scab developed only moderately on most varieties.

A detailed statement of materials, concentrations, and results is presented in the appendix in Tables 8 to 13.

EXPERIMENTS AT BELDING

The Orchard—The orchard at Belding, Ionia County, is on the farm of the Hall Orchards, Inc. The trees were planted in 1902, entirely of Baldwin, but a considerable number of McIntosh trees have been set to replace Baldwin trees that died out. Many of these McIntosh trees are only two or three years younger than the Baldwins. The block used for experimental spraying covers about eight acres. The orchard has been cultivated each year, except for the areas immediately under the trees. In many seasons, a cover crop of oats has been sown in the late summer. The trees, in general, are in good vigor.

In addition to this block of mature trees, extensive experiments were carried on in 1929 in a 10-year old block of McIntosh, Duchess, and Gano on the same farm. Records could not be taken from McIntosh because of a very light crop. This orchard has had clean cultivation and was disced close to the trees before growth began.

Spraying Equipment and Methods—A spraying outfit with a rated capacity of 15 gallons per minute and operated with an eight H. P. engine was used. The spraying was all done with a spray gun of the standard, single nozzle type. In 1925, 1926, and 1927 a disc aperture of 3/16 of an inch and a pressure of 350 pounds were used but in 1928 and 1929 it was possible to use only a 9/64 of an inch disc aperture because of decreased efficiency of the pump. In 1928, the pressure could not be maintained uniformly or at as high a point as was desired. These conditions, together with the fact that the spraying was done from the ground that year, are reflected in the degree of control obtained. The spraying was done from the top of the sprayer tank, except in 1928 when a long hose was used and the operator worked from the ground.

Schedule and Dates of Application—A five-application schedule consisting of the prepink, pink, petal-fall, two weeks, and second brood was followed in this orchard. The dates of these applications for each year appear in Table 2.

Table 2.—Dates of application at Belding.

Application	1925	1926	1927	1928	1929
Prepink	April 28, 29	May 11, 12	April 22, 23	May 4, 5	April 10, 11, 12, 15*
Pink	May 6, 7	May 18	May 6, 7	May 8, 9	May 6
Petal-fall	May 23, 25	June 3, 4	May 26	May 28, 29	May 29, 31
Two weeks	June 4, 6	June 19	June 9, 10	June 11, 12	June 14, 15
Second brood	July 17, 18	Aug. 4	Aug. 5, 6	Aug. 9, 10	Aug. 5

*Rain, snow, and storms made spraying very difficult and, in fact, impossible at times, consequently this application was prolonged unduly.

Supplementary Materials—Nicotine sulphate (40%) has been used in the prepink application at the rate of three-fourths to one pint in each 100 gallons of spray. Lead arsenate has been used regularly in the pink, petal-fall, two weeks, and second brood sprays. It was used, previous to 1928, at the rate of two pounds in 100 gallons in all these applications but in 1928 and 1929 three pounds were used in all except the second brood spray when the amount was reduced to two pounds. The only exceptions to this were the pink application in 1929, when six pounds to each 100 gallons were used for leaf-roller control (this was not done in the younger orchard) and, in 1928, when calcium arsenate was used, as indicated, in two plots.

Scab Development—Conditions were such in 1925 and 1926 that development was relatively light, but, in 1927, 1928, and 1929, scab developed freely where unchecked by spraying.

A detailed tabular statement of materials, concentrations, and results is presented in the appendix in Tables 14 to 20.

EXPERIMENTS AT FENNVILLE

The Orchard—In 1927, several materials were tested in an orchard near Fennville, Allegan county. The trees are mature and the orchard includes several varieties, but the greater portion of the work was confined to Duchess and Winter Banana. This orchard stands in light sandy soil. Neither cultivation nor mulching was practiced and, since nitrogenous fertilizers had not been applied recently, the trees were not in vigorous condition.

Spraying Equipment and Methods—The spraying was done with a sprayer equipped with a two cylinder pump operated with a three H. P. engine and giving a delivery of five to six gallons per minute. The pressure was maintained at 225 to 250 pounds. A spray gun was used at all times and the spraying was done with the operator standing on top of the sprayer tank and completing a row as a unit, spraying one side, then the other.

Schedule and Dates of Applications—Six applications were made as follows: prepink, April 24 and 25; pink, May 4, 5, and 6; petal-fall, May 20, 21 and 23; two-weeks, June 6, 7, 8 and 9; and second-brood application August 4, 5, and 6. The Winter Banana trees received another application in early July. Duchess trees were not sprayed in the second-brood application.

Supplementary Materials—Lead arsenate was used in the pink, petal-fall, two-weeks, and second-brood applications at the rate of two pounds in 100 gallons.

Scab Development—Apple scab developed in this orchard on unsprayed trees to an extent seldom seen. This was due largely to three factors: quantities of heavily infected leaves on the ground, susceptible varieties, and conditions extremely favorable to scab development throughout the first half of the summer. In this connection, it should be stated that the number of applications made in this orchard was not adequate to give complete control of scab even with the most effective materials. The results, however, are strictly comparable for the various materials used.

A tabular statement of materials, concentrations, and results is presented in Tables 21 to 23.

EXPERIMENTS AT GRAND RAPIDS

The Orchard—Tests were made at the Graham Horticultural Experiment Station in 1929 in an orchard planted in 1919. Most of the trees were under a sod mulch system of management and were in moderate vigor. There are several varieties in the orchard and all were sprayed but records were obtained only from those indicated in the tabular statements of results.

Schedule and Dates of Applications—A schedule of five applications was followed in this orchard. This consisted of the prepink, pink, petal-fall, two-weeks, and second-brood applications.

Supplementary Materials—Nicotine sulphate at the rate of one pint in each 100 gallons of dilute spray was used in the prepink, and lead arsenate was used in the pink, petal-fall, and two-weeks applications at the rate of three pounds in each 100 gallons of dilute spray and at the rate of two pounds in the second-brood application.

Scab Development—There were no check trees in this experiment but scab was generally severe in this district and there is evidence that it would have developed freely on Duchess if unchecked but probably only to a moderate degree on Grimes.

A tabular statement of materials, concentrations, and scab development is presented in Table 24.

DISCUSSION OF RESULTS

SEASONAL DEVELOPMENT OF SCAB

The results of several of the experiments reported in this bulletin are inconclusive because scab did not develop seriously on unsprayed trees. This condition prevailed in 1925 and 1926 at Morrice (see Tables 9 and 10) and at Belding (see Tables 14 and 15). At Morrice, there was practically no scab on unsprayed Jonathan and Hubbardston trees (varieties that are only moderately susceptible to scab) and at Belding only a slight development on McIntosh, a very susceptible variety.

Scab development varies not only from season to season but from one orchard to another. For example, in 1927 and 1929, scab was present in epidemic form on McIntosh at Belding and to a serious degree in 1928. No tabular results for McIntosh at Belding in 1929 are available because of crop failure, but unsprayed trees of this variety were badly defoliated by the unusually severe development of scab. At Morrice (Tables 11, 12, and 13) scab was severe but far from epidemic in 1927. It developed only moderately in 1928 and very irregularly in 1929. These statements are based not only on the counts of scabby fruits but on frequent observations throughout the season.

The point is this: satisfactory results in one year in scab control do not prove the merit of any material or method. The lack of merit of a material may sometimes be definitely determined in a single trial but, in general, repeated trials under many conditions are necessary before definite conclusions can be drawn. Considerable risk is taken by growers who adopt new procedures on the basis of satisfactory performance in one trial in their orchard or because of favorable results in another orchard or district.

SPECIAL SULPHUR PREPARATIONS

Several special sulphur materials have been tested, and, in general, they have been found to be much less effective than lime-sulphur. Results from the use of colloidal sulphurs are presented in Table 8, (plots 6 and 7) where 53.5 and 48.4 per cent of the fruit was scabby, as compared to 2.2 per cent where lime-sulphur was used (plot 1). In Table 12 (plot 16) another colloidal sulphur is shown to have allowed 17.5 per cent of Hubbardston and 13.9 per cent of Wagener to become scabby as compared to 2.0 and 1.1 per cent for the same varieties with lime-sulphur (plot 11). This was in 1928, a year when scab was not difficult to control in this orchard. In Table 22, a colloidal sulphur (plot 15) and a so-called "activated" sulphur (plot 16) are shown to be definitely inferior to lime-sulphur (plot 1). The number of applications in this orchard, previously mentioned, was not sufficient to give complete control with any material, but even under such conditions lime-sulphur sprayed trees had 54 and 53 per cent less of badly scabbed fruit, C grade, than trees sprayed with colloidal and activated sulphurs.

Sulfocide has been used in several instances and has produced fair to good results in years of light scab development (refer to Table 9, plot 1, and to Table 15, plot 5). In years when scab was difficult to control, Sulfocide has not given satisfactory results. This is shown definitely in Table 16 (plot 5) where there is 29.1 per cent of scabby fruit as compared with 4.2 per cent with lime-sulphur (plot 3) and again in Table 22, where there is a difference between Sulfocide (plot 17) and lime-sulphur (plot 1) of 36 per cent in total scab and 56 per cent in badly scabbed or C grade fruit.

The evidence, therefore, shows definitely that the special sulphur preparations and Sulfocide used in these experiments were not equal to lime-sulphur in the control of scab, and, under severe conditions, some of them have been almost worthless.

DRY-MIX SULPHUR-LIME AND WETTABLE SULPHUR

The substitution of dry-mix or wettable sulphur for lime-sulphur for the control of apple scab for all or part of the applications has been advocated to a certain extent during recent years. The principal points in favor of the dry-mix and wettable sulphur preparations is the fact that very little injury to foliage and fruit occurs when they are used. This is important but there remain other questions such as cost, ease of handling, and fungicidal value. Of these, fungicidal value is undoubtedly the most important and data which are significant in this connection are presented in this report.

In Table 8, plot 4, the substitution of dry-mix for lime-sulphur in the after-blossom applications, is shown to have permitted scab to develop to the extent of 16.5 per cent, and, when it was used for all applications, 27.5 per cent of the fruit was scabby (plot 5). This was in contrast to only 2.2 per cent of scabby fruit with the all-season use of lime-sulphur (plot 1). In Table 10, plot 1, the results from the use of wettable sulphur were not significant as the unsprayed trees (plot 14) had very little scab.

Significant results were obtained in 1927, as presented in Table 11. A wettable sulphur was substituted for lime-sulphur, in one instance in the two-weeks and second-brood applications and in another in the petal-fall, two-weeks and second-brood applications. In still another plot lime-sulphur was used for all applications. It should be stated in this connection that the second-brood application was not significant in this experiment as the weather was unfavorable to scab development after mid-summer. Comparing the results from the three treatments, it is found that the total scab for the all-season use of the lime-sulphur (plot 8) was 3.7, 6.6, and 3.4 per cent, respectively, for Jonathan, Hubbardston, and McIntosh. The substitution of wettable sulphur in the two-weeks application (plot 9) resulted in scabby apples to the extent of 18.4, 10.2, and 17.1 per cent for the three varieties, and the further substitution of wettable sulphur in the petal-fall as well as in the two-weeks application (plot 10) allowed scab to increase to 39.7, 15.3, and 25.7 per cent, respectively, for the three varieties.

Similar substitution of dry-mix at Belding in 1927 on McIntosh (Table 16, plot 2) did not result in a large increase in scab over that found with lime-sulphur (plot 3). Two factors may have been operative here in making for less difference than that shown in the preceding paragraph. First, the peak of scab development came considerably later at Morrice than at Belding, and, second, there were approximately 16 pounds of actual sulphur in each 100 gallons of spray used at Belding, while at Morrice there were less than eight pounds of actual sulphur in each 100 gallons.

The tests at Fennville in 1927, included dry-mix and wettable sulphur used on Duchess and Winter Banana. As previously stated, scab developed to an unusual degree in this orchard in 1927, and further, the number of applications was not great enough to give complete control, even with the most effective material. These points should be taken into consideration when studying these results, but the fact remains that the treatment was exactly the same with all materials and the results, therefore, are comparable.

Wettable sulphur (Table 23, plot 18) and lime-sulphur (plot 1) show

81 and 20 per cent, respectively, of badly scabbed, C grade, fruit, a significant difference. The wettable sulphur used here was the same as that used at Morrice (Table 11, plots 9 and 10).

In Table 23, are presented the results from the use of dry-mix sulphur-lime made up with four grades of sulphur and each at two concentrations, 16 and 24 pounds of dry-mix per 100 gallons of spray. Considering plots 23, 24, 25, and 26, there are no significant differences in results with the several types of sulphur when used at the rate of 16 pounds of the mixture to 100 gallons. Of slightly scabby, B grade, apples, the range was from 24 to 35 per cent, for badly scabbed, C grade, 62 to 75 per cent and total scab 96 to 99 per cent. The averages of the four materials for B grade, C grade, and total scab respectively were 31, 66, and 97. In plots 27, 28, 29, and 30, where the same mixtures were used, at the higher concentration of 24 pounds, scab control was far from satisfactory but there is evidence that the larger amount of sulphur gave slightly better control. The range of B grade was from 32 to 41 per cent, C grade 46 to 53 per cent, and total scab 80 to 95 per cent. The averages for the three grades respectively were 37, 53, and 89, as compared with 31, 66, and 97 for the smaller amount of sulphur.

Dry-mix and wettable sulphur have merit in some respects but they undoubtedly have a much lower fungicidal value than lime-sulphur at the usual concentration. When used in the regular way under conditions favorable to scab development, unsatisfactory results may be expected.

DRY LIME-SULPHUR

Dry lime-sulphur has been available for a number of years but there still remains some confusion as to the merits of this material when compared with liquid lime-sulphur. Dry lime-sulphur is made by dehydrating or drying liquid lime-sulphur, but, usually with the addition of a material called a "stabilizer," to check the breaking down of the sulphur compounds contained in the lime-sulphur. Cane sugar is often used for this purpose. Liquid lime-sulphur is made up largely of calcium polysulphides, together with some calcium thiosulphate. Dry lime-sulphur, therefore, may be expected to have compounds of a similar nature and it is upon these compounds that its effectiveness depends. It seems reasonable to assume, then, that similar results might be expected from using quantities of liquid and dry lime-sulphur which would yield approximately equal amounts of sulphur containing compounds. Chemical analyses* have shown that four pounds of dry lime-sulphur are required to give the same amount of active ingredients as are contained in one gallon of 33° Baume lime-sulphur solution. An effort has been made to determine whether this "4 to 1" ratio is correct and if the presence of cane sugar increases the fungicidal value of dry lime-sulphur.

Studies with dry lime-sulphur have been made in several experiments. In some of these scab development was so slight, on sprayed and unsprayed trees alike, that the results are not significant. Such instances are shown in Table 9, plots 7, 10, and 11; Table 10, plots, 9,

*The Preparation of Spray Materials. R. H. Robinson, Bulletin 201, Oregon Agricultural College Experiment Station, January, 1924.

12, 13, and 14; and Table 15, plots 7, 8, and 9. However, scab developed seriously in several orchards and comparisons were possible.

Consider first, the results of the work on Duchess at Fennville in 1927. Liquid lime-sulphur was used at four concentrations: two and one-half, two, one and one-half, and one gallon with water to make 100 gallons. In comparison with this one brand of dry lime-sulphur was used at four concentrations: ten, eight, six, and four pounds in each 100 gallons of dilute spray. These amounts are equivalent, according to the 4 to 1 ratio, to the respective quantities of liquid lime-sulphur just stated. Another brand of dry lime-sulphur was used at three concentrations: ten, eight, and six pounds in 100 gallons. This work was done, as previously mentioned, in an orchard where scab was unusually severe and where the spraying schedule was not adequate to give complete control even with the most effective materials, but, since the treatments for the several materials were the same, the results are strictly comparable.

Results reported in Table 21, plots 1 to 12, show that there are neither large nor significant differences in the slightly scabbed, B grade, fruit but that there are definite trends in the percentages of badly scabbed, C grade, fruit. For instance, in plots 1, 2, 3, and 4 there is a general increase in the amount of C grade fruit with each decrease in concentration. The only exception to this is in plot 2, which has more than the lower concentrations, but this may possibly be explained on the basis of the fruit from that plot being from the tops of trees where there was more scab. Again in plots 5, 6, 7, and 8 with dry lime-sulphur A, each decrease in concentration resulted in a definite increase in C grade fruit. For ten, eight, six, and four pounds, there are respectively 17, 24, 39, and 50 per cent of badly scabbed fruits; and again, in plots 9, 10, and 11 with dry lime-sulphur B at the rate of ten, eight, and six pounds, there are 23, 42, and 62 per cent of badly scabbed apples. This is definite evidence that at least four pounds of dry lime-sulphur are necessary to afford protection against apple scab equal to one gallon of 33° Baume lime-sulphur solution.

The work just discussed and presented in Table 21 was repeated in 1929 at Belding and results are presented for Duchess and Gano in Table 19. Conditions in this experiment were very comparable with those prevailing at Fennville: that is, scab was very severe and the number of applications was not adequate for perfect control with any material; but again, the results with all materials are strictly comparable. This condition is not desirable in commercial work, but, in comparative tests of this sort, a slightly inadequate schedule is probably preferable to more frequent or extremely heavy spraying as the latter procedure tends to mask differences between materials.

Referring to Table 19, and considering the results obtained from the four concentrations, it is evident that there is much more C grade and total scab with the lowest concentration of each material than with the highest concentration. This is shown by comparing, for both Duchess and Gano, the results obtained in plot 1 with those in plot 4; plot 5 with plot 8; and plot 9 with plot 12. The results from the intermediate concentrations are somewhat irregular, but the general trend is towards more scab with each reduction in concentration of the material.

Further comparison shows the results, as a whole, from the use of lime-sulphur in plots 1, 2, 3, and 4 to have been considerably better than with dry lime-sulphur B in plots 9, 10, 11, and 12; and the results from dry lime-sulphur B better than with dry lime-sulphur A in plots 5, 6, 7, and 8. The differences between results obtained with materials in the 1929 experiment at Belding are greater than at Fennville in 1927; and the dry lime-sulphur A gave better results than B in 1927, but B gave better results than A in 1929.

The result of other tests, comparing dry and liquid lime-sulphur, are presented in several instances. These tests were made by using liquid lime-sulphur at the rate of two and one-half gallons and dry lime-sulphur at the rate of 10 pounds with water to make 100 gallons. These are equivalent amounts according to the the assumed "4 to 1" ratio. At Belding in 1927, dry lime-sulphur A and B (Table 16, plots 7 and 8) gave results with McIntosh essentially the same as liquid lime-sulphur (plot 3). Scab developed in epidemic form in this experiment as partly indicated by the amount of scab on unsprayed fruit (plot 9). At Morrice in 1929, equivalent amounts of liquid and dry lime-sulphur (Table 13, plots 7 and 8) gave essentially equal results with Jonathan, Baldwin, and Spy. The amounts of scab were slightly greater in each instance with dry than with liquid lime-sulphur. These differences are not large but suggest that four pounds of dry lime-sulphur are slightly less effective than one gallon of the liquid, especially since scab was not difficult to control in this orchard. Similar comparisons were made at Belding with Baldwin and McIntosh in 1929 in a mature orchard. The results with Baldwin are presented in Table 18, plots 2 and 3, and dry lime-sulphur is again shown to have given slightly less satisfactory control than liquid lime-sulphur, Records of scab development on the fruit of McIntosh are not available because these trees failed to set fruit, but the development of scab on the foliage was distinctly more severe with dry than with liquid lime-sulphur.

The results of these experiments show definitely: first, that for the control of apple scab, four pounds or more of dry lime-sulphur are required to equal one gallon of liquid lime-sulphur testing 32° to 33° Baume; and, second, there is no indication that the presence of cane sugar or other stabilizer increases the effectiveness of the dry lime-sulphur. The general recommendations for the use of liquid lime-sulphur call for two and one-half gallons in each 100 gallons of dilute spray. The conclusions just stated show that 10 pounds or more of the dry would be required to equal the two and one-half gallons of liquid lime-sulphur. This is much more than is usually recommended by the manufacturers of dry lime-sulphur. Smaller amounts of the dry have given satisfactory results in many instances but it is certain that correspondingly reduced amounts of liquid lime-sulphur also would have given equally satisfactory results.

Composition of Dry Lime-Sulphur—It has been stated in a foregoing paragraph that chemical analyses have shown that four pounds of dry lime-sulphur and one gallon of the liquid concentrate contain approximately equal amounts of active ingredients. In order to check this with the materials used in 1929, the active ingredients in several

samples of liquid and dry lime-sulphur were determined.* The composition is shown in Table 3.

Table 3.—Composition of liquid and dry lime-sulphur used in 1929.

	Total sulphur	Thiosulphate sulphur	Free sulphur	Total Polysulphides
	Per cent	Per cent	Per cent	Per cent
Dry lime-sulphur A	61.5	1.9	6.5	68.0
Dry lime-sulphur A	60.8	2.1	8.3	66.2
Dry lime-sulphur B	60.4	3.0	3.9	69.5
Liquid lime-sulphur 1	27.1	1.0	.....	33.1
Liquid lime-sulphur 2	25.8	1.0	.....	31.3
Liquid lime-sulphur 3	26.4	1.0	.....	31.3

Calculating from these figures and using 10.75 pounds as the weight of one gallon of liquid lime-sulphur and averaging the three samples of each class, the following equivalents are shown for the materials used in 1929. When calculated on the basis of total sulphur, 4.7 pounds of dry are shown to be necessary to yield the same amount of sulphur as one gallon of the liquid; and, when figured on the basis of total polysulphides, 5 pounds of the dry are required to equal one gallon of the liquid concentrate. This makes a ratio of 4.7 to 1 on the basis of total sulphur and 5 to 1 on the basis of total polysulphides and is different enough from the assumed ratio of 4 to 1 to explain in part, at least, the differences in results obtained in the field in 1929.

LIME AND OTHER MATERIALS IN COMBINATION WITH LIME-SULPHUR AND DRY LIME-SULPHUR

Many modifications of the lime-sulphur-lead arsenate combination have been suggested. Some of these modifications are supposed to increase the fungicidal value of the spray, but more of them have been made to reduce injury to fruit and foliage. The relation of all of these modifications to scab control is important, however, and many observations have been made in this connection.

Lime—The most commonly used modifying material is lime. One instance of its use is found in Table 8 (plot 2) where 4.9 per cent of Hubbardston apples were scabby as compared with 2.2 per cent with lime-sulphur (plot 1). This difference is not large and in itself probably not significant. All of the unsprayed fruit (plot 8) was scabby. The results in 1925 and 1926 at Morrice (Table 9, plot 4 and Table 10, plot 4) and at Belding (Table 14, plot 4 and Table 15, plot 4) are not significant because of the light development of scab in those years. At Morrice in 1928, the use of lime in all or part of the applications, with lime sulphur and **lead arsenate,** did not result in material differences in scab control. In this connection, plots 1 and 2, Table 12, are comparable with plot 3. In another part of this orchard, lime was used with

*The analyses were made through the co-operation of W. C. Geagley, Analyst, Michigan Department of Agriculture, Lansing, Michigan.

lime-sulphur and **calcium arsenate** (plot 15) which is comparable with plot 11, where no lime was used. In this instance, the addition of lime resulted in a definite but not large increase in scab. It is possible that the difference in the arsenical may have been a factor here. Lime was also used at Belding in 1928 (Table 17, plots 7 and 8) and there are apparent differences in results for which, however, other factors such as method of application are probably responsible. The use of lime discussed in this paragraph has been with lime-sulphur at the rate of two and one-half gallons in 100, and scab control has not been affected greatly although there is an indication that the addition of lime slightly reduced the fungicidal value of the spray.

At Fennville in 1927, lime was used with relatively low concentrations of lime-sulphur and dry lime-sulphur. The results of this work are presented in Table 21, plots 13 and 14. In plot 13, lime-sulphur was used at the prepink and pink stages at the rate of one and one-half gallons in 100 and in the petal-fall and two-weeks applications at one gallon in 100. Hydrated lime was added each time. The results in this plot where lime was used were less satisfactory than where lime-sulphur at the rate of one gallon, but without lime, (plot 4) was used for all applications. A similar condition is shown with the dry lime-sulphur in plot 14, where the addition of lime to dry lime-sulphur at the rate of six pounds in 100 gallons for part of the applications, and four pounds for the others, gave poorer control than that secured where all the applications were made with dry lime-sulphur, four pounds in 100, but without lime (plot 8). The conclusion drawn from the results of the use of lime with lime-sulphur and dry lime-sulphur is that, when used with relatively high concentrations, there is possibly some but not a serious effect on the fungicidal action; but, when used with low concentrations of liquid or dry lime-sulphur and under severe conditions, the effect may be more pronounced.

Casein Spreader—The addition of casein spreader to the lime-sulphur-lead arsenate spray has been suggested to reduce certain types of spray injury and also to increase the effectiveness of the spray. Both these effects have been studied, and evidence on scab control is presented from several experiments. At Morrice, in 1924, (Table 8, plots 1 and 3) very little difference in results is shown. Control was almost perfect in 1925 and 1926 at Morrice (Table 9, plot 3 and Table 10, plot 3); at Belding, (Table 14, plot 2 and Table 15, plot 2) the results are not significant because scab did not develop seriously, even on unsprayed trees.

The result of the only experiment where casein spreader was used when scab developed freely shows no diffrence of consequence, in fact it was impossible to improve on the results obtained from lime-sulphur without casein spreader added. It is obvious that with thorough spraying with lime-sulphur at the concentration used in these tests, there is no reason to add casein spreader for the purpose of improving scab control. Evidence is not available with regard to the use of casein spreader with low concentrations of lime-sulphur, nor do any statements made here have any reference to the relation of the spreader to the effectiveness of lead arsnate, with or without lime-sulphur, in codling moth control.

Other Materials—Several other modifying materials have been used, largely for the purpose of reducing foliage injury. Among these are

cane sugar (Table 9, plot 6 and Table 14, plot 6); calcium sulphate (Table 12, plot 4) and tobacco dust (Table 12, plot 5 and Table 17, plot 2). No significant differences in scab control through the use of these materials were found, and, since there was little or no improvement from the standpoint of foliage injury, the use of these materials was not continued.

IRON SULPHATE WITH LIME-SULPHUR AND DRY LIME-SULPHUR

The addition of iron sulphate (ferrous sulphate) to the lime-sulphur-lead arsenate spray has resulted in a marked reduction in one type of foliage injury. Facts concerning the fungicidal value of the combination are important and information in this connection is presented from numerous experiments. The use of this combination was begun at both Morrice and Belding in 1925 but the results with scab control for that year and for 1926 in both orchards are not significant because of the light development of scab. The results of these experiments are presented in Table 9, plot 5; Table 10, plot 5; Table 14, plot 5; and Table 15, plot 6.

In other experiments, different amounts of iron sulphate in combination with lime-sulphur have been used and there also have been many variations in the applications in which the iron sulphate was used. A consideration of the data for each experiment will show the trend of results. At Morrice in 1927, a comparison of iron sulphate in two plots (Table 11, plots 5 and 6) with two plots without iron sulphate (plots 1 and 8) indicates, in general, slightly more scab where the iron sulphate was used.

In 1928, (Table 12) a comparison of plots 3 and 11, which did not have iron sulphate, with plots 6, 7, and 14, which had iron sulphate in several applications, show small and insignificant differences. Again, in 1929 (Table 13) there are no significant differences between plots 2 and 8 and plots 1, 3, 4, 5, 6, 10, 11 and 12. Plot 11 was sprayed with dry instead of liquid lime-sulphur.

The results at Belding show in 1927 (Table 16) slightly more scab with iron sulphate (plot 6) than where it was not used (plot 3). The iron sulphate was used here at the rate of three and one-half pounds for each gallon of lime-sulphur concentrate, instead of the one-half pound used in most instances. This increase probably would lower the fungicidal value of the spray. In 1928, there was a greater difference between plots 6 and 3 (Table 17). Some of this difference may have been due to the materials used, but the method of application undoubtedly also influenced these results. In Table 18 are shown the results with Baldwin at Belding in 1929 and there was slightly less scab without iron sulphate (plot 3) than with the various combinations of iron sulphate with lime-sulphur, as shown in plots 4, 5, and 6. Dry lime-sulphur with and without iron sulphate (plots 2 and 7) cannot be compared because of the lack of trees of this variety in one plot. Other work at Belding with young trees of Duchess and Gano shows no differences between lime-sulphur with and without iron sulphate. It was not used in plots 13, 21, and 22 (Table 20) but was added in one or more

applications in plots 14, 16, 17, 19, and 20. The substitution of dry lime-sulphur for the liquid in plots 15 and 18 was followed by the development of much more scab, but these results are practically the same as with the similar concentrations of dry lime-sulphur shown in Table 19, plot 5, where the dry lime-sulphur was used without iron sulphate.

In still another experiment, a comparison is available, at Grand Rapids in 1929 (Table 24). There are no significant differences between the results in plot 1, which did not have any iron sulphate, and plots 2 and 3, which did have it. In plot 4, where weak bordeaux was used in the pre-pink application, there was considerably more scab on Duchess but not on Grimes.

A review of these results with iron sulphate in combination with lime-sulphur and lead arsenate shows, in some instances, slight differences in the control of apple scab. In other instances, there has been no significant difference. The addition of iron sulphate to the lime-sulphur and lead arsenate spray may lower the fungicidal value to a slight extent but it is believed that little difficulty is probable if the spraying is done thoroughly and is properly timed. Any possible difference is more than compensated for by the improvement in the condition of the foliage.

ALUMINUM SULPHATE WITH LIME-SULPHUR

The modification of lime-sulphur with aluminum sulphate is practiced to a considerable extent in certain districts, and evidently with satisfactory results. The combination of aluminum sulphate, lime-sulphur, and lead arsenate was used in two orchards in 1927. At Morrice, (Table 11, plot 7) scab development was slightly greater than with lime-sulphur (plot 8) and about the same as where iron sulphate was used. At Belding, with McIntosh, (Table 16, plot 4) there was considerably more scab than with lime-sulphur (plot 3) or with lime-sulphur and iron sulphate (plot 6). Foliage injury was severe at Morrice, especially on Jonathan; and, in this connection, it may be said that the more recent use of aluminum sulphate in other districts is with lime-sulphur and calcium arsenate rather than with lime-sulphur and lead-arsenate. Evidence is not available now to justify the substitution, under Michigan conditions, of calcium arsenate for lead arsenate.

BORDEAUX

Bordeaux has been used continuously, beginning in 1925, on one plot in the orchard at Morrice and likewise at Belding. In the later tests, lime-sulphur or the lime-sulphur and iron sulphate combination has been substituted in the petal-fall application to reduce russeting. This bordeaux has been of low concentration at all times. The 4-8-100 formula was used in 1925 and after that the 2-2-100 concentration was used. At Morrice, there were no significant differences in scab development between the bordeaux and the lime-sulphur sprayed trees from 1925 to 1928 inclusive. Refer to Table 9, plots 8 and 9; Table 10,

plots 10 and 11; Table 11, plots 8 and 11 and Table 12, plots 11 and 12. In 1929, however, there was more scab with bordeaux (Table 13, plot 9) than with lime-sulphur in plot 8. A similar condition prevailed at Belding for the same period except that there was slightly more scab with bordeaux than with lime-sulphur in 1928. The results are presented in Tables 14, 15, 16, and 17 and in plots 1 and 3 in each. In 1929, at Belding, (Table 18) there was much more scab with bordeaux (plot 1) than with lime-sulphur (plot 3). The results in the young orchard at Belding in 1929 (Table 20) show generally that more scab developed when the weak bordeaux was used in the prepink application than when lime-sulphur or lime-sulphur and iron sulphate were used. In this connection plot 16 is comparable with 17, and 15 with 18. Another similar comparison is available in the results of the work at Grand Rapids in 1929 (Table 24). The use of bordeaux in plot 4, in the prepink application, did not give as satisfactory results with Duchess as the use of lime-sulphur, with or without iron sulphate, in that application (plots 1, 2, and 3).

The evidence here presented shows that, in many instances, weak bordeaux has given satisfactory scab control. Under some conditions, however, the results have not been equal to those obtained from the use of lime-sulphur. The indication is, therefore, that the low concentrations of bordeaux cannot always be counted on to give satisfactory control of apple scab.

LEAD ARSENATE AND SCAB DEVELOPMENT

The fact has long been known that, under some conditions, the addition of lead arsenate to lime-sulphur increases the fungicidal value of the spray. Definite evidence in this connection was obtained at Morrice in 1927. The data are presented in the appendix in Table 11. The materials used in each 100 gallons of spray are listed there and also in Table 4.

Table 4.—Lime-sulphur and lead arsenate combinations.

Plot 1	Lime-sulphur, 2½ gal.	Lead arsenate, 2 pounds
Plot 2	Lime-sulphur, 2½ gal.	Lead arsenate, 1 pound
Plot 3	Lime-sulphur, 2½ gal.	Lead arsenate, none
Plot 4	Lime-sulphur, 1¼ gal.	Lead arsenate, none

Plots 1, 2, and 3 received the same concentrations of lime-sulphur, two and one-half gallons, but the lead arsenate was reduced to one pound in plot 2, and none was used in plot 3. In plot 4, the lime-sulphur was cut in half and no lead arsenate was used. The increases in actual scab for each plot over that found in plot 1 are shown in Table 5.

A reduction in the amount of lead arsenate in plot 2 resulted in an increase in scab; its elimination in plot 3 resulted in a still greater increase, and half strength lime-sulphur with no lead arsenate in plot 4 gave still less satisfactory results. This is simply further evidence that lead arsenate, when used with lime-sulphur on apples, has merit other than as an insecticide.

Table 5.—Lead arsenate and scab control.

Plot	Increase in Scab (per cent)	
	Jonathan	Hubbardston
2	4.3	1.5
3	14.1	5.0
4	19.8	13.9

Another test of this sort was made in 1926 (Table 10, plots 6, 7 and 8) but results are not conclusive because scab did not develop.

CALCIUM ARSENATE AND SCAB DEVELOPMENT

Calcium arsenate has been reported to have merit as a fungicide and observations have been made in this connection with apple scab. The evidence available from these experiments is not extensive and does not justify any definite conclusion, but the indications are that the addition of calcium arsenate to lime-sulphur does not affect the fungicidal action in the same way as lead arsenate since scab development was greater with the calcium arsenate. Lime was used with the calcium arsenate and this may have been a factor. The results from the use of calcium arsenate are presented in Table 12, plot 15; and Table 17, plots 4 and 5.

SEASONAL USE OF FUNGICIDES

A question frequently asked in connection with the spraying of apples is "Cannot the fungicide be omitted or the concentration lowered in the second-brood or even in the two-weeks application?" A definite answer that will apply to all orchards or to any one orchard in all seasons is impossible. The necessity for a fungicide in the late summer sprays depends, first, on the degree of control attained in the early part of the season, and, second, on weather, in late summer, which is favorable to scab development. If control is complete in the early part of the year, there is no occasion to use a fungicide in late summer. This goal is not reached in many instances, and, if it is not, there is always the possibility of late scab. Under such conditions, the elimination of the fungicide from the second-brood application may result disastrously.

A limited amount of data in this connection is presented in this report. At Fennville in 1927, a year when scab was epidemic, certain eliminations and substitutions were made. In plot 19, Table 23, lime-sulphur was used in all applications and with the results shown. In plot 20, lime-sulphur was eliminated after the two-weeks application with an appreciable increase in scab; in plot 21, the fungicide was omitted after the petal-fall application with a still greater increase in scab. Dry-mix was substituted for lime-sulphur in the two-weeks and second-brood applications in plot 22. The results were very similar to those shown for plot 21, where the fungicide was omitted from those applications.

In 1927 at Morrice, a wettable sulphur was substituted for lime-sulphur in certain applications. As shown in Table 11, plot 8 received lime-sulphur in all applications; in plot 9, wettable sulphur was substituted in the two-weeks and second-brood applications; and, in plot 10, the substitution was made in the petal-fall, two-weeks, and second-brood applications.

The differences are shown in Table 6.

Table 6.—Substitution of wettable sulphur for lime-sulphur in part of applications.

Plot	Apples Scabby (Per cent)		
	Jonathan	Hubbardston	McIntosh
8	3.7	6.6	3.4
9	18.4	10.2	17.1
10	39.7	15.3	25.7

These differences were due entirely to the use of the ineffective wettable sulphur in the petal-fall and two-weeks applications, as the second-brood spray played no part in scab control in this experiment.

At Morrice in 1928, (Table 12) plots 8, 9, 10, and 11 were all sprayed alike in the pre-blossom applications, but in the after-blossom applications, the amounts of lime-sulphur used for 100 gallons of spray were: plot 8, one gallon; plot 9, one and one-half gallons; plot 10, two gallons and plot 11, two and one-half gallons. Scab was not difficult to control with fully effective materials, but in spite of this condition, slightly more scab developed with the lower concentrations than with the higher ones. The results are summarized in Table 7.

Table 7.—Effect of lowering concentrations of lime-sulphur in part of applications.

Plot	Apples Scabby (Per cent)	
	Jonathan	Hubbardston
8	6.3	3.6
9	6.3	2.3
10	1.9	2.9
11	1.3	2.0

These results from the substitution, omission, or reduction in concentration of fungicides in certain applications emphasize one point; namely, when conditions are favorable for scab development, whether it be in early spring or mid-summer, an effective fungicide is essential.

WHAT CONCENTRATION OF LIME-SULPHUR IS BEST

The concentration of lime-sulphur recommended, in the current issue of the Michigan Spraying Calendar, is two and one-half gallons, with water to make 100 gallons. In making this recommendation, it is fully

realized that under some conditions lower concentration is possible, and even desirable, in part or all of the applications.

Many factors are operative in this connection. Varieties differ widely in susceptibility to scab; scab development varies from season to season and from orchard to orchard; the frequency of application is important; the rate of application, the amount used per tree, bears a very definite relation to concentration; these and other factors should all be considered in determining what concentration is desirable.

The question, "What concentration of lime-sulphur is best?" can be answered only in one way, "There is no one concentration that is best in all seasons, for all varieties, or for every grower."

Good judgment, which comes only with experience, must be exercised in deciding this question. If there is any doubt as to the best procedure, the safe course is to use two and one-half gallons of liquid lime-sulphur with water to make 100 gallons, or an equivalent amount of dry lime-sulphur.

SUMMARY

Apple scab does not develop seriously every year nor in all orchards even in years when scab is generally epidemic. These conditions make repeated tests necessary before a material or method can be definitely recommended for general use.

Several specially prepared sulphur sprays such as colloidal and "activated" sulphur and Sulfocide have not given satisfactory control of apple scab under all conditions and have even been very unsatisfactory in several instances.

Dry-mix sulphur-lime and wettable sulphurs are much less effective in the control of apple scab than lime-sulphur. Scab has developed seriously in several instances where these materials were substituted for lime-sulphur in the after-blossom applications.

Dry lime-sulphur and liquid lime-sulphur have been used on the basis of four pounds of the dry having approximately the same amount of active ingredients as one gallon of the liquid concentrate. Results, in general, have been comparable when used on this 4 to 1 ratio. In some instances, however, the dry lime-sulphur did not equal the liquid when used on this basis. Chemical analyses of the materials used in that work show that 4.7 to 1 was necessary to give an equivalent amount of total sulphur and 5 to 1 for total polysulphides. The results of this work indicate definitely that for the control of apple scab four pounds or more of dry lime-sulphur are required to equal one gallon of lime-sulphur concentrate.

The addition of lime to liquid and dry lime-sulphur has not increased the fungicidal value of the spray, but has, in some instances, actually decreased the fungicidal action. This was more noticeable with the lower concentrations of lime-sulphurs.

Casein spreader in combination with the higher concentration, two and one-half gallons in 100, of lime-sulphur has not increased the value of the spray.

The addition of calcium sulphate and tobacco dust to the lime-sulphur

spray has not affected scab control. The results from the use of cane sugar in this way are not conclusive.

The use of iron sulphate at the rate of one-half pound for each gallon of lime-sulphur concentrate has not affected scab control in a significant way. The fungicidal value was slightly lower in some instances but in general there have not been significant differences.

Aluminum sulphate combined with lime-sulphur and lead arsenate has not given satisfactory results.

Bordeaux, of low concentration, has usually given satisfactory scab control but in a few instances the results have not been comparable with those obtained with lime-sulphur. The indication is that a concentration greater than 2-2-100 is necessary to insure control under all conditions.

Lead arsenate and lime-sulphur combined is more active in the control of apple scab than lime-sulphur alone.

The value of calcium arsenate as a fungicide is not clearly indicated in these experiments.

The omission of lime-sulphur or the substitution of a less effective material in the after-blossom applications is frequently practiced. This procedure, however, is often hazardous as scab development may continue well into the summer in some years.

The optimum concentration of lime-sulphur or dry lime-sulphur cannot be definitely stated for all seasons or all growers. This must be determined by experience by each grower and is influenced by many factors.

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APPENDIX

Table 8.—Experiments at Morrice, 1924.

Plot	Materials	Amount in 100 gal. dilute spray	Apples Scabby (Per cent)
			Hubbardston
1	Lime-sulphur	2½ gal.	2.2
2	Lime-sulphur	2½ gal.	
	Hydrated lime	10 lbs.	4.9
3	Lime-sulphur	2½ gal.	1.9
	Casein spreader	1 lb.	
4	Lime-sulphur (prepink and pink)	2½ gal.	
	Dry-mix sulphur-lime (all after blossom sprays)	25 lbs.	16.5
5	Dry-mix sulphur-lime (all applications)	25 lbs.	27.5
6	Colloidal sulphur I	10 lbs.	53.5
7	Colloidal sulphur II	½ lb.	48.4
8	Unsprayed		100.0

Table 9.—Experiments at Morrice, 1925.

Plot	Materials	Amount in 100 gals.	Apples Scabby (Per cent)	
			Jonathan	Hubbardston
1	Sulfocide	1 gal.	0	0
2	Lime-sulphur	2½ gal.	0	0
3	Lime-sulphur	2½ gal.	0	0
	Casein spreader	2 lbs.		
4	Lime-sulphur	2½ gal.		
	Quick lime	5 lbs.	0	0
5	Lime-sulphur	2½ gal.	0	0
	Iron sulphate	1¼ lbs.		
6	Lime-sulphur	2½ gal.	0	0
	Cane sugar	5 oz.		
7	Dry lime-sulphur A	8 lbs.	0	0
8	Lime-sulphur (Same as Plot 2)	2½ gal.	0	0
9	Bordeaux	4–8–100	0	0
10	Dry lime-sulphur A	10 lbs.	0	0
11	Check—unsprayed		0	0.3

Table 10.—Experiments at Morrice, 1926.

Plot	Materials	Amount in 100 gals.	Apples Scabby (Per cent)	
			Jonathan	Hubbardston
1	Lime-sulphur (pink and petal-fall applic.)	2½ gal.	0.3	0.1
	Wettable sulphur (two-weeks and 2nd brood applic.)	10 lbs.		
2	Lime-sulphur	2½ gal.	0	0
3	Lime-sulphur	2½ gal.	0.1	0
	Casein spreader	1 lb.		
4	Lime-sulphur	2½ gal.		
	Quick lime	5 lbs.	0.1	0.2
5	Lime-sulphur	2½ gal.	0	0.6
	Iron sulphate	1¼ lbs.		
6	Lime-sulphur (no lead arsenate at any time)*	1¼ gal.	0	0.3
7	Lime-sulphur	1¼ gal.	0	0.3
	Lead arsenate	1 lb.		
8	Lime-sulphur	2½ gal.	0	0
	Lead arsenate	1 lb.		
9	Dry lime-sulphur A	10 lbs.	0	0.4
10	Lime-sulphur (same as Plot 2)	2½ gal.	0	0
11	Bordeaux	2–2–100	0	0.5
12	Dry lime-sulphur A	8 lbs.	0.1	0.3
13	Dry lime-sulphur A	6 lbs.	0.1	0
14	Check—unsprayed		16.0	1.3

*Lead arsenate was used at the rate of 2 lbs. in 100 gal. on all plots except Nos. 6, 7, and 8.

Table 11.—Experiments at Morrice, 1927

Plot	Materials	Amount in 100 gals. dilute spray	Apples Scabby (Per cent)								
			Jonathan			Hubbardston			McIntosh		
			B	C	Total	B	C	Total	B	C	Total
1	Lime-sulphur	2½ gal.*	1.7	0.3	2.0	2.8	2.1	4.9			
	Lead arsenate	2 lbs.									
2	Lime-sulphur	2½ gal.*	6.0	0.3	6.3	3.8	2.6	6.4			
	Lead arseante	1 lb.									
3	Lime-sulphur	2½ gal.*	14.0	2.1	16.1	6.6	3.3	9.9			
	Lead arsenate	none									
4	Lime-sulphur	1¼ gal.*	19.7	2.1	21.8	12.2	6.6	18.8			
	Lead arsenate	none									
5	Lime-sulphur	2½ gal.*	4.3	1.3	5.6	4.2	4.7	8.9	1.6	1.1	2.7
	Iron sulphate	1¼ lbs.									
	Lead arsenate	2 lbs.									
6	Lime-sulphur	2½ gal.*	4.2	0	4.2	6.4	3.5	9.9	7.8	1.7	9.5
	Iron suplhate	8¾ lbs.									
	Lead arsenate	2 lbs.									
7	Lime-sulphur	2½ gal.*	5.6	0.2	7.6	5.4	3.5	8.9	3.0	1.1	4.1
	Aluminum sulphate	8¾ lbs.									
	Lead arsenate	2 lbs.									
8	Lime-sulphur	2½ gal.*	3.3	0.4	3.7	3.8	2.8	6.6	2.6	0.8	3.4
	Lead arsenate	2 lbs.									
9	Lime-sulphur (pink and petal fall)	2½ gal.*	18.3	0.1	18.4	6.5	3.7	10.2	16.5	0.6	17.1
	Wettable sulphur (two-weeks and second brood)	8 lbs.									
	Lead arsenate (all applic.)	2 lbs.									
10	Lime-sulphur (pink)	2½ gal.*									
	Wettable sulphur (petal-fall, two weeks and second brood)	8 lbs.	37.7	2.0	39.7	10.2	5.1	15.3	23.6	2.1	25.7
	Lead arsenate (all applic.)	2 lbs.									
11	Bordeaux	2–2–100	3.2	0	3.2	5.9	3.6	9.5			
	Lead arsenate	2 lbs.									
12	Check (unsprayed)		52.5	32.9	85.4	49.6	27.6	77.2			

*Lime-sulphur was used in the "two-weeks" and "second-brood" applications at a slightly lower concentration. 2 gals. in 100 gals. of dilute spray were used in Plots 1, 2, 3, 5, 6, 7, 8, 9, and 10; and 1 gal. in 100 on Plot 4. The amounts of ferrous sulphate in Plots 5 and 6 and of aluminum sulphate in Plot 7 were reduced proportionately.

Table 12.—Experiments at Morrice, 1928.

Plot	Materials	Amount in 100 gals. dilute spray	Apples Scabby (Per cent)								
			Jonathan			Hubbardston			Wagener		
			B	C	Total	B	C	Total	B	C	Total
1	Lime-sulphur	2½ gal.									
	Quick lime (in petal-fall, two-weeks and second brood applic.)	8 lbs.	.....	.....	.....	1.3	0.1	1.4			
2	Lime-sulphur	2½ gal.									
	Quick lime (in all applic.)	8 lbs.	0.7	0	0.7	0.1	0.3	0.4			
3	Lime-sulphur	2½ gal.	0.8	0	0.8	0	0	0			
4	Lime-sulphur	2½ gal.	0.1	0	0.1	0.3	0	0.3			
	Calcium sulphate*	4 lbs.									
5	Lime-sulphur	2½ gal.	0.3	0	0.3	0	0.1	0.1			
	Tobacco dust*	5 lbs.									
6	Lime-sulphur } (All applic. except last)	2½ gal.	1.5	0.4	1.9	1.7	0.3	2.0			
	Iron sulphate } (All applic. except last)	1¼ lbs.									
	Bordeaux (last applic.)	2–2–100									
7	Lime-sulphur } (All applic. except last)	2½ gal.	2.8	0	2.8	0.5	0.1	0.6			
	Iron sulphate } (All applic. except last)	2½ lbs.									
	Bordeaux (last applic.)	2–2–100									
8	Lime-sulphur (in pre-blossom sprays)	2½ gal.	5.9	0.4	6.3	3.5	0.1	3.6			
	Lime-sulphur (in post-blossom sprays)	1 gal.									
9	Lime-sulphur (in pre-blossom applic.)	2½ gal.	5.6	0.7	6.3	2.0	0.3	2.3			
	Lime-sulphur (in post-blossom applic.)	1½ gal.									
10	Lime-sulphur (in pre-blossom applic.)	2½ gal.	1.9	0	1.9	2.6	0.3	2.9			
	Lime-sulphur (in post-blossom applic.)	2 gal.									
11	Lime-sulphur	2½ gal.	1.3	0	1.3	1.0	1.0	2.0	1.1	0	1.1
12	Bordeaux (in all applic. except petal-fall)	2–2–100	2.2	0	2.2	0.3	0.1	0.4			
	Lime-sulphur (in petal-fall applic.)	2½ gal.									
13	Bordeaux (in all applic. except petal-fall)	2–2–100	0	0	0	0.8	0.1	0.9			
	Lime-sulphur } (in petal-fall applic.)	2½ gal.									
	Iron sulphate } (in petal-fall applic.)	1¼ lbs.									
14	Bordeaux (in prepink, and second-brood sprays)	2–2–100	0	0	0	0.8	0.3	1.1			
	Lime-sulphur } (in pink, petal-fall and two weeks)	2½ gal.									
	Iron sulphate } (in pink, petal-fall and two weeks)	1¼ lbs.									
15	Lime-sulphur	2½ gal.									
	Calcium arsenate	2 lbs.	.....	.....	.....	5.9	0.7	6.6			
	Quick lime*	8 lbs.									
16	Colloidal sulphur	10 lbs.	.....	.....	.....	15.8	1.7	17.5	13.5	0.4	13.9
17	Check—unsprayed	.....	62.3	28.1	90.4	57.1	37.7	94.8	74.2	4.2	78.8

*Added in all applications when arsenate was used.

Table 13.—Experiments at Morrice, 1929.

Plot	Materials	Amount in 100 gals. dilute spray	Apples Scabby (Per cent)								
			Jonathan			Baldwin			Spy		
			B	C	Total	B	C	Total	B	C	Total
1	Bordeaux (prepink and second-brood applic.)	2–2–100									
	Lime-sulphur + Iron sulphate (pink, petal-fall and two weeks applic.)	2½ gal. + 1¼ lbs.	0.2	0	0.2	1.4	0	1.4			
2	Lime-sulphur (all applic.)	2½ gal.	1.3	0	1.3	0.3	0	0.3			
3	Lime-sulphur (prepink)	2½ gal.									
	Lime-sulphur + Iron sulphate + Casein spreader (pink, petal-fall and two-weeks applic.)	2½ gal. + 1¼ lbs. + 1 lb.	0.4	0	0.4	0.9	0	0.9	0	0	0
	Bordeaux (second-brood applic.)	2–2–100									
4	Lime-sulphur (prepink, pink and petal-fall applic.)	2½ gal.									
	Lime-sulphur + Iron sulphate (two-weeks applic.)	2½ gal. + 1¼ lbs.	1.2	0	1.2	1.9	0	1.9	1.1	0	1.1
	Bordeaux (second-brood applic.)	2–2–100									
5	Lime-sulphur + Iron sulphate (prepink, pink, petal-fall and two-weeks applic.)	2½ gal. + 1¼ lbs.	0.4	0	0.4	2.8	0	2.8	0.3	0	0.3
	Bordeaux (second-brood applic.)	2–2–100									
6	Lime-sulphur (prepink applic.)	2½ gal.									
	Lime-sulphur + Iron sulphate (pink, petal-fall, and two-weeks applic.)	2½ gal. + 1¼ lbs.	0	0	0	1.0	0	1.0	0.7	0	0 7
	Bordeaux (second-brood)	2–2–100									
7	Dry lime-sulphur A (all applic.)	10 lbs.	2.5	0	2.5	4.1	0	4.1	3.5	0	3.5
8	Lime-sulphur (all applic.)	2½ gal.	0.5	0	0.5	3.4	0	3.4	1.6	0	1.6
9	Bordeaux (all applic. except petal-fall)	2–2–100									
	Lime-sulphur + Iron sulphate (petal-fall applic.)	2½ gal. + 1¼ lbs.	4.1	0	4.1	11.4	0	11.4	9.1	0	9.1
10	Dry lime-sulphur A (prepink applic.)	10 lbs.									
	Dry lime-sulphur + Iron sulphate (pink, petal-fall and two weeks applic.)	10 lbs. + 1¼ lbs.	1.2	0	1.2	0.3	0	0.3	1.8	0	1 8
	Bordeaux (second brood applic.)	2–2–100									
11	Same as Plot 6		0.4	0	0.4				3.5	0	3 5
12	Same as Plot 1		1.6	0	1.6				1.8	0	1 8
13	Check		42.2	6.3	48.5				58.1	25.5	83 6

Table 14.—Experiments at Belding, 1925.

Plot	Materials	Amount in 100 gals.	Apples scabby (Per cent)
			McIntosh
1	Bordeaux	4–8–100	3.4
2	Lime-sulphur	2½ gal.	
	Casein spreader	1 lb.	0
3	Lime-sulphur	2½ gal.	1.1
4	Lime-sulphur	2½ gal.	
	Quick lime	5 lbs.	2.0
5	Lime-sulphur	2½ gal.	3.3
	Iron sulphate	1¼ lbs.	
6	Lime-sulphur	2½ gal.	0.8
	Cane sugar	5 oz.	
7	Check—unsprayed		16.5

Table 15.—Experiments at Belding, 1926.

Plot	Materials	Amount in 100 gals.	Apples scabby (Per cent)
			McIntosh
1	Bordeaux	2–2–100	0.5
2	Lime-sulphur	2½ gal.	0.7
	Casein spreader	1 lb.	
3	Lime-sulphur	2½ gal.	0.1
4	Lime-sulphur	2½ gal.	0.2
	Quick lime	4 lbs.	
5	Sulfocide	½ gal.	4.7
6	Lime-sulphur	2½ gal.	0.8
	Iron sulphate	1¼ lb.	
7	Dry lime-sulphur A	10 lbs.	0.1
8	Dry lime-sulphur B	10 lbs.	0.2
9	Check—unsprayed		39.5

Table 16.—Experiments at Belding, 1927

Plot	Materials	Amount in 100 gal.	Apples Scabby (Per cent)		
			McIntosh		
			B	C	Total
1	Bordeaux	2–2–100	3.7	2.3	6 0
2	Lime-sulphur (prepink, pink and petal-fall applic.)	2½ gal.	4.7	2.7	7 4
	Dry-mix (two weeks and second-brood applic.)	25 lbs.			
3	Lime-sulphur	2½ gal.	2.2	2.0	4 2
4	Lime-sulphur	2½ gal.	10.9	9.2	20 1
	Aluminum sulphate	8¾ lbs.			
5	Sulfocide	½ gal.	14.7	14.4	29 1
6	Lime-sulphur	2½ gal.	6.6	5.2	11.8
	Iron sulphate	8¾ lbs.			
7	Dry lime-sulphur A	10 lbs.	3.1	1.5	4 6
8	Dry lime-sulphur B	10 lbs.	3.1	2.2	5 3
9	Check—unsprayed		5.5	94.0	99 5

Table 17.—Experiments at Belding, 1928.

Plot	Materials	Amount in 100 gal.	Apples Scabby (Per cent) McIntosh		
			B	C	Total
1	Bordeaux (all applic. except petal fall)	2–2–100			
	Lime-sulphur (petal-fall applic.)	2½ gal.	7.1	6.1	13.2
	Iron sulphate (petal-fall applic.)	1¼ lbs.			
2	Lime-sulphur	2½ gal.			
	Tobacco dust*	5 lbs.			
3	Lime-sulphur	2½ gal.	9.7	1.4	11.1
4	Lime-sulphur	2½ gal.			
	Calcium arsenate**	2 lbs.	35.6	6.8	42.4
	Quick lime*	8 lbs.			
5	Lime-sulphur	2½ gal.			
	Calcium arsenate** (used in prepink, pink, petal-fall and two weeks applic.)	2 lbs.			
	Iron sulphate (used in prepink, pink, petal-fall and two weeks applic.)	1¼ lbs.	24.2	11.5	35.7
	Bordeaux (second-brood applic.)	2–2–100			
	Calcium arsenate (second-brood applic.)	2 lbs.			
6	Lime-sulphur (pre-pink, pink, petal-fall and two weeks	2½ gal.	19.7	6.1	25.6
	Iron sulphate applic.)	1¼ lbs.			
	Bordeaux (second-brood applic.)	2–2–100			
7	Lime-sulphur (lime used in all applic.)	2½ gal.	15.8	13.5	29.3
	Quick lime (lime used in all applic.)	8 lbs.			
8	Lime-sulphur (lime used in petal-fall, two weeks and	2½ gal.	8.5	0.5	9.0
	Quick lime second-brood applic.)	8 lbs.			
9	Check—unsprayed		0	100.	100.

*Added only when arsenical was used.
**Lead arsenate was used in the usual way on all other plots.

Table 18.—Experiments at Belding, 1929.

Plot	Materials	Amount in 100 gal.	Apples Scabby (Per cent) Baldwin		
			B	C	Total
1	Bordeaux (all applications except petal-fall)	2–3–100*			
	Lime-sulphur (petal-fall applic. only)	2½ gal.	29.9	17.5	47.4
	Iron sulphate (petal-fall applic. only)	1¼ lbs.			
2	Dry lime-sulphur A	10 lbs.	14.5	1.8	16.3
3	Lime-sulphur	2½ gal.	9.0	1.1	10.1
4	Lime-sulphur (prepink applic.)	2½ gal.			
	Lime-sulphur (pink, petal-fall and two weeks applic.)	2½ gal.	16.5	1.8	18.3
	Iron sulphate (pink, petal-fall and two weeks applic.)	1¼ lbs.			
	Bordeaux (second-brood applic.)	2–3–100*			
5	Bordeaux (prepink applic.)	2–3–100*			
	Lime-sulphur (pink, petal-fall and two weeks applic.)	2½ gal.	11.7	0.5	12.2
	Iron sulphate (pink, petal-fall and two weeks applic.)	1¼ lbs.			
	Bordeaux (second-brood applic.)	2–3–100*			
6	Lime-sulphur (prepink, pink, petal-fall and two weeks	2½ gal.			
	Iron sulphate applic.)	1¼ lbs.	14.5	1.2	15.7
	Bordeaux (second brood applic.)	2–3–100*			
7	Dry lime-sulphur A (prepink, pink, petal-fall and two weeks	10 lbs.			
	Iron sulphate applic.)	1¼ lbs.			
	Bordeaux (second-brood applic.)	2–3–100*	No Baldwin trees in this plot.		
8	Check—no treatment		Lost entire crop, largely from scab injury.		

*Hydrated lime.

Table 19.—Experiments at Belding (Young Orchard), 1929.

Plot	Materials	Amount in 100 gal.	Apples Scabby (Per cent)					
			Duchess			Gano		
			B	C	Total	B	C	Total
1...	Lime-sulphur	2½ gal.	25.1	8.6	33.7	14.9	0	14.9
2...	Lime-sulphur	2 gal.	34.1	8.9	43.0	18.9	5.8	24.7
3...	Lime-sulphur	1½ gal.	36.2	15.6	51.8	22.0	7.1	29.1
4...	Lime-sulphur	1 gal.	39.2	20.9	60.1	21.9	3.8	25.7
5...	Dry lime-sulphur A	10 lbs.	33.7	50.0	83.7	29.8	18.3	48.1
6...	Dry lime-sulphur A	8 lbs.	32.7	50.8	83.5	33.0	27.9	60.9
7...	Dry lime-sulphur A	6 lbs.	27.7	65.9	93.6	26.9	48.0	74.9
8...	Dry lime-sulphur A	4 lbs.	22.9	70.6	93.5	31.2	46.2	77.4
9...	Dry lime-sulphur B	10 lbs.	36.2	27.6	63.8	21.5	8.3	29.8
10...	Dry lime-sulphur B	8 lbs.	32.6	42.5	75.1	23.6	21.6	45.2
11...	Dry lime-sulphur B	6 lbs.	34.7	37.3	72.0	30.6	17.2	47.8
12...	Dry lime-sulphur B	4 lbs.	33.8	38.7	72.5	29.1	29.7	58.8
23...	Check—unsprayed		12.8	87.2	100.			

Table 20.—Experiments at Belding (Young Orchard), 1929.

Plot	Materials	Amount in 100 gal.	Apples Scabby (Per cent)					
			Duchess			Gano		
			B	C	Total	B	C	Total
13...	Lime-sulphur	2½ gal.	22.2	11.1	33.3	16.1	5.1	21.2
14...	Lime-sulphur \ (prepink, pink, petal and two	2½ gal.						
	Iron sulphate / weeks applic.)	1¼ lbs.	27.1	4.5	31.6	25.5	11.1	26.6
	Bordeaux (second-brood applic.)	2-3-100*						
15...	Dry lime-sulphur A \ (prepink, pink, petal-fall	10 lbs.						
	Iron sulphate / and two weeks applic.)	1¼ lbs.	42.8	39.1	81.9	31.4	19.6	51.0
	Bordeaux (second-brood applic.)	2-3-100*						
16...	Lime-sulphur (prepink applic.)	2½ gal.						
	Lime-sulphur \ (pink, petal-fall and two	2½ gal.						
	Iron sulphate / weeks applic.)	1¼ lbs.	20.3	2.3	32.6	11.2	2.2	13.4
	Bordeaux (second-brood applic.)	2-3-100*						
17...	Bordeaux (prepink applic.)	2-3-100*						
	Lime-sulphur \ (pink, petal-fall and two	2½ gal.						
	Iron sulphate / weeks applic.)	1¼ lbs.	41.9	6.8	48.7	16.3	3.4	19.7
	Bordeaux (second-brood applic.)	2-3-100*						
18...	Bordeaux (prepink applic.)	2-3-100*						
	Dry lime-sulphur A \ (pink, petal-fall and two	10 lbs.						
	Iron sulphate / weeks applic.)	1¼ lbs.	37.0	56.6	93.6	27.3	10.2	37.5
	Bordeaux (second-brood applic.)	2-3-100*						
19...	Lime-sulphur (prepink and pink applic.)	2½ gal.						
	Lime-sulphur \ (petal-fall and two weeks	2½ gal.						
	Iron sulphate / applic.)	1¼ lbs.	28.3	3.9	32.2			
	Bordeaux (second-brood applic.)	2-3-100*						
20...	Lime-sulphur (prepink, pink and petal-fall applic.)	2½ gal.						
	Lime-sulphur \ (two weeks applic.)	2½ gal.						
	Iron sulphate /	1¼ lbs.	20.6	5.1	25.7			
	Bordeaux (second-brood applic.)	2-3-100*						
21...	Lime-sulphur (prepink, pink, petal-fall and two weeks applic.)	2½ gal.	31.1	3.7	34.8			
	Bordeaux (second-brood applic.)	2-3-100*						
22...	Lime-sulphur	2½ gal.	26.8	3.7	30.5			
23...	Check—unsprayed		12.8	87.2	100.			

*Hydrated lime

Table 21.—Experiments at Fennville, 1927.

Plot	Materials	Amount in 100 gal.	Apples Scabby (Per cent)		
			Duchess		
			B	C	Total
1	Lime-sulphur	2½ gal.	41	20	61
2	Lime-sulphur	2 gal.	38	34	72
3	Lime-sulphur	1½ gal.	41	28	69
4	Lime-sulphur	1 gal.	47	31	78
5	Dry lime-sulphur A	10 lbs.	37	17	54
6	Dry lime-sulphur A	8 lbs.	37	24	61
7	Dry lime-sulphur A	6 lbs.	39	39	78
8	Dry lime-sulphur A	4 lbs.	31	50	81
9	Dry lime-sulphur B	10 lbs.	41	23	64
10	Dry lime-sulphur B	8 lbs.	40	43	83
11	Dry lime-sulphur B	6 lbs.	28	62	88
12	Dry lime-sulphur B	4 lbs.			
13	Lime-sulphur (prepink and pink applic.)	1½ gal.	44	43	87
	Lime-sulphur (petal-fall and two weeks applic.)	1 gal.			
	Hydrated lime (all applic.)	10 lbs.			
14	Dry lime-sulphur A (prepink and pink applic.)	6 lbs.			
	Dry lime-sulphur A (petal-fall and two weeks applic.)	4 lbs.	30	62	92
	Hydrated lime (all applic.)	10 lbs.			

Table 22.—Experiments at Fennville, 1927.

Plot	Materials	Amount in 100 gals.	Apples Scabby (Per cent)		
			Duchess		
			B	C	Total
15	Colloidal sulphur	10 lbs.	22	74	96
16	Activated sulphur	8 lbs.	23	73	96
17	Sulfocide	½ gal.	21	76	97
18	Wettable sulphur	8 lbs.	16	81	97
1	Lime-sulphur	2½ gal.	41	20	61

Table 23.—Experiments at Fennville, 1927.

Plot	Materials	Amount in 100 gal.	Apples Scabby (Per cent)		
			Winter Banana		
			B	C	Total
19	Lime-sulphur (all applic.)	2½ gal.	32	17	49
20	Lime-sulphur (prepink, pink, petal-fall and two weeks applications; no fungicide in second-brood applic.)	2½ gal.	37	19	56
21	Lime-sulphur (prepink, pink and petal-fall applic.; no fungicide in two weeks and second-brood applic.)	2½ gal.	46	22	68
22	Lime-sulphur (prepink, pink and petal-fall applic.)	2½ gal.			
	Dry-mix—300 mesh sulphur (two weeks and second-brood applic.)	24 lbs.	41	31	72
23	Dry-mix—200 mesh sulphur (all applic.)	16 lbs.	24	72	96
24	Dry-mix—300 mesh sulphur (all applic.)	16 lbs.	32	65	97
25	Dry-mix—colloidal sulphur (all applic.)	16 lbs.	35	62	97
26	Dry-mix—sublimed sulphur (all applic.)	16 lbs.	33	66	99
27	Dry-mix—200 mesh sulphur (all applic.)	24 lbs.	41	52	93
28	Dry-mix—300 mesh sulphur (all applic.)	24 lbs.	35	53	88
29	Dry-mix—colloidal sulphur (all applic.)	24 lbs.	34	46	80
30	Dry-mix—sublimed sulphur (all applic.)	24 lbs.	32	63	95

Table 24.—Experiments at Grand Rapids, 1929.

Plot	Materials	Amount in 100 gal.	Apples Scabby (Per cent)					
			Duchess			Grimes		
			B	C	Total	B	C	Total
1	Lime-sulphur (all applic.)	2½ gal.	9.7	1.9	11.6	2.3	0	2.3
2	Lime-sulphur (prepink applic.)	2½ gal.						
	Lime-sulphur | (pink, petal-fall and two	2½ gal.	8.8	1.0	9.8	1.3	0	1.3
	Iron sulphate / weeks applic.)	1¼ lbs.						
	Bordeaux (second-brood applic.)	2–3–100*						
3	Lime-sulphur | (prepink, pink, petal-fall and	2½ gal.						
	Iron sulphate / weeks applic.)	1¼ lbs.	10.0	2.0	12.0	1.9	0	1.9
	Bordeaux (second-brood applic.)	2–3–100*						
4	Bordeaux (prepink applic.)	2–3–100*						
	Lime-sulphur | (pink, petal-fall and two	2½ gal.						
	Iron sulphate / weeks applic.)	1¼ lbs.	23.7	10.7	34.4	1.9	0	1.9
	Bordeaux (second-brood applic.)	2–3–100*						

*Hydrated lime.